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DAFTAR PUSTAKA

Ahmed, H.A., T.Y. Xin, and Y.Q. Chang. 2020. Optimal control of environmental conditions affecting lettuce plant growth in a controlled environment with artificial lighting: a review. South African Journal of Botany. 130: 75-89.

Ai, N.S. dan P. Torey. 2013. Karakter morfologi akar sebagai indikator kekurangan air pada tanaman. Jurnal Bios Logos. 3(1): 31-39.

Akter, A., S. Akhter, and M.M. Hossain. 2025. Water stresses alter the growth, yield, and quality of broccoli (*Brassica oleracea* var. italica). Scientific Reports. 15: 40107.

Alcade, A.L.D., C.P. Sinco, M.L.S. Cantor, M.T. Vina, J.R. Garcia-Bolanos, and R.J.B. Bordios. 2022. Effects of varying nutrient solutions to *Brassica rapa* "Bokchoy" grown under hydroponic system. American Journal of Environment and Climate (AJEC). 1(2): 31-37.

Amir, H.F. 2024. Optimization of Nutrient Levels, pH, Electrical Conductivity, and Temperature for Enhanced Growth of *Brassica rapa chinensis* Using a Wick System Hydroponic. Faculty of Science. Thesis.

Amitrano, C., C. Arena, Y. Rouphael, S.D. Pascale. 2019. Vapour pressure deficit: the hidden driver behind plant morphofunctional traits in controlled environment. Annals of Applied Biology. 175(3): 313-325.

Anastasya, N.A., A.M. Putra, S.W. Rachmawati, I. Trianti, A. Setiawan, A.L. Abadi, and L.Q. Aini. 2024. Impact of plant growth-promoting bacteria on the growth performance and resistance enzymes of tatsoi mustard in a hydroponic system. Biodiversitas. 25(8): 3309-3317.

Anggraeny, F., E. Gusmayanti, and C.J.K. Simamora. 2025. Growth and yield response of pagoda mustard to nitrogen fertilizer and biostimulant application on podzolic soil. Agrotechnology Research Journal. 9(1): 42-48.

Anhar, T., D.W. Respatie, dan A. Purwantoro. 2022. Kajian pertumbuhan dan hasil lima aksesi kacang hijau (*Vigna radiata* L.). Vegetalika. 11(4): 292-304.

Ashok, A.D. and E. Sujitha. 2020. Hydroponic vegetable cultivation. International Journal of Chemical Studies. 8(5): 1207-1213.

Asgar, A. 2017. Pengaruh suhu penyimpanan dan jumlah perforasi kemasan terhadap karakteristik fisik dan kimia brokoli (*Brassica oleracea* var. Royal G) *fresh cut*. Jurnal Hortikultura. 27(1): 127-136.

Atikah, S.S. 2023. Pengaruh Konsentrasi AB Mix dengan Penambahan Pupuk Organik Cair dan Jenis Media Tanam Terhadap Pertumbuhan dan Hasil Tanaman Pagoda Secara Hidroponik NFT. Program Studi Teknologi Produksi Tanaman Hortikultura. Politeknik Negeri Lampung. Skripsi.

Awasthi, P. 2023. Application and importance of crop physiology in horticulture. Reviews in Food and Agriculture. 4(2): 28-31.

Baantasik, E.T. 2025. Evaluasi Kinerja Saluran Irigasi Daerah Irigasi Sampe

UNIVERSITAS GADJAH MADA
Pengaruh Supplementary Light dan Pemupukan Kalium terhadap Morfo-Fisiologis dan Kualitas Sawi Pagoda (Brassica narinosa L.) pada Sistem Hidroponik Nutrient Film Technique (NFT)
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Kecamatan Sesean Kabupaten Toraja Utara. Program Studi Teknik Sipil. Fakultas Teknik. Universitas Kristen Indonesia Toraja. Skripsi.

Bahamonde, H.A., C. Pimentel, L.A. Lara, V.B. Fernandez, and V. Fernandez. 2023. Foliar application of potassium salts to olive, with focus on accompanying anions. Plants. 12(3): 472.

Binu, S. 2024. What is Tatsoi? Uses, Nutrition, Health Benefits, Recipe, and Side Effects. <https://www.netmeds.com/c/health-library/post/what-is-tatsoi-uses-nutrition-health-benefits-recipe-and-side-effects?>. Diakses 10 April 2026.

BPS. 2023. Statistik Jumlah Pelaku Usaha Pertanian Perorangan Subsektor Menurut Wilayah Indonesia. <https://sensus.bps.go.id/topik/tabular/st2023/233/0/0>. Diakses 18 Desember 2025.

BPS. 2023. Tabel Statistik Produksi Tanaman Sayuran Indonesia. <https://www.bps.go.id/id/statistics-table/2/NjEjMg==/produksi-tanaman-sayuran.html>. Diakses 10 April 2026.

BPS. 2024. Statistik Impor Sayuran Menurut Negara Asal Utama. <https://www.bps.go.id/id/statistics-table/1/MjAwOSMx/impor-sayuran-menurut-negara-asal-utama--2018-2023.html>. Diakses 18 Desember 2025.

BPS. 2025. Statistik Jumlah Penduduk Menurut Kelompok Umur dan Jenis KelaminIndonesia. <https://www.bps.go.id/id/statistics-table/3/WVc0%20MGEyMXBkVFUxY25KeE9HdDZkbTQzWkVkb1p6MDkjMw==/jumlah-penduduk-menurut-kelompok-umur-dan-jenis-kelamin--2023.html>. Diakses 18 Desember 2025.

Brini, F., K. Mseddi, M. Brestic, and M. Landi. 2022 Hormone-mediated plant responses to light quality and quantity. Environmental and Experimental Botany. 202: 105026.

Cahyanda, R.Q., H. Agustin, dan A.R. Fauzi. 2022. Pengaruh metode penanaman hidroponik dan konvensional terhadap pertumbuhan tanaman selada romaine dan pakcoy. Jurnal Bioindustri. 4(2): 109-119.

Cheng, T., R. Song, D. Li, K. Zhou, H. Zheng, X. Yao, Y. Tian, W. Cao, and Y. Zhu. 2017. Spectroscopic estimation of biomass in canopy components of paddy rice using dry matter and chlorophyll indices. Remote Sensing. 9:319.

Cheng, M.C., P.K. Kathare, I. Paik., and E. Huq. 2021. Phytochrome signaling networks. Annual Review of Plant Biology. 72: 217-244.

Choudhary, M., S. Kumar, S. Onte, V.K. Meena, D. Malakar, K. Garg, S. Kumar, M.V.S. Rajawat, M.K. Awasthi, B.S. Giri, D.K. Jaiswal, S. Dhar, E.A. Azman, S.A. Kochewad. 2024. Optimizing crop quality and yield: assessing the impact of integrated potassium management on chinese cabbage (*Brassica rapa* L. subsp. *chinensis*). Heliyon. 10(17): 1-10.

Debangshi, U. 2021. Crop microclimate modification to address climate change. International Journal of Research and Review. 8(9): 384-395.

UNIVERSITAS
GADJAH MADA
Pengaruh Supplementary Light dan Pemupukan Kalium terhadap Morfo-Fisiologis dan Kualitas Sawi Pagoda
(Brassica narinosa L.) pada Sistem Hidroponik Nutrient Film Technique (NFT)
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Deo, R.C., R.H. Grant, A. Webb, S. Ghimire, D.P. Igoe, N.J. Downs, M.S. Al-Musaylh, A.V. Parisi, and J. Soar. 2022. Forecasting solar photosynthetic photon flux density under cloud cover effects: novel predictive model using convolutional neural network integrated with long short-term memory network. Stochastic Environmental Research and Risk Assessment. 36: 3183-3220.

Dewi, A., N. Lubis, dan S.M.B Sitepu. 2022. Budidaya Selada Organik Ramah Lingkungan. Penerbit Tahta Media Group, Indonesia.

Direktorat Jenderal Hortikultura. 2024. Angka Tetap Hortikultura Tahun 2023. Direktorat Jenderal Hortikultura, Kementerian Pertanian. <https://hortikultura.pertanian.go.id/wp-content/uploads/2024/04/buku_atap_2023.pdf>. Diakses pada 15 Desember 2025.

Dwiratna, S., K. Amaru, and M.A. Nanda. 2022. The potential of hydroponic kit-based growing on a self fertigation system for pagoda mustard (*Brassica narinosa* L.) production. Hindawi: The Scientific World Journal. 5(1): 1-13.

Egorova, K.V., N.G. Sinyavina, A.M. Artemyeva, N.V. Kocherina, and Y.V. Chesnokov. 2021. QTL analysis of the content of some bioactive compounds in *Brassica rapa* L. grown under light culture conditions. Horticulture. 7(12): 1-22.

Faust, J.E. and J. Logan. 2018. Daily light integral: a research review and high-resolution maps of the United States. Hort Science. 53(9): 1250-1257.

Fulazzaky, M.A. 2014. Challenges of integrated water resources management in Indonesia. Water Journal. 6: 2001-2020.

Gardner, F.P., R.B. Peace, and R.L. Mitchell. 1991. Physiology of Crop Plants. Iowa State University Press, United States of America.

Gendron, J.M. and D. Staiger. 2023. New horizons in plant photoperiodism. Annual Review in Plant Biology. 74: 481-509.

Gustianty, L.R. dan T.G.H. Saragih. 2020. Tanggap tanaman sawi pagoda (*Brassica narinosa* L.) terhadap media tanam dan pupuk NPK pada pipa paralon. Prosiding Seminar Nasional "Sinergi Hasil Penelitian Dalam Menghasilkan Inovasi Di Era Revolusi 4.0", Kisaran, 19 September 2020.

Handayani, N.A. and D. Ariyanti. 2012. Potency of solar energy applications in Indonesia. International Journal of Renewable Energy Development. 1(2): 33-38.

Harahap, M.A., F. Harahap, and T. Gultom. 2020. The effect of AB mix nutrients on the growth and yield of pakchoi (*Brassica chinensis* L.) plants under hydroponic wick system conditions. Journal of Physics: Conference Series. 1485(1): 1-9.

Haynes, R.J. and K.M. Goh. 1977. Review on physiological pathways of foliar absorption. Scientia Horticulturae. 7: 291-302.

Hopkins, W.G. and N.P.A. Hüner. 2009. Introduction To Plant Physiology. 4th ed. Wiley, United States of America.

UNIVERSITAS
GADJAH MADA
Pengaruh Supplementary Light dan Pemupukan Kalium terhadap Morfo-Fisiologis dan Kualitas Sawi Pagoda
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Hu, W., Z. Lu, F. Meng, X. Li, R. Cong, T. Ren, T.D. Sharkey, and J. Lu. 2020. The reduction in leaf area precedes that in photosynthesis under potassium deficiency: the importance of leaf anatomy. New Phytologist. 227: 1749-1763.

Huang, W., D.A. Ratkowsky, C. Hui, P. Wang, J. Su, and P. Shi. 2019. Leaf fresh weight versus dry weight: which is better for describing the scaling relationship between leaf biomass and leaf area for broad-leaved plants. Forests. 10(3): 256.

Husni, M.M. 2026. Pengaruh Pengamatan Tinggi Tanaman dan Jumlah Daun Terhadap Pertumbuhan Tanaman Jagung Manis (*Zea mays saccharata*). Fakultas Pertanian. Universitas Borobudur. Disertasi.

Javed, H.H., Y. Hu, A. Raza, M.A. Asghar, X. Peng, A. Ullah, and Y.C. Wu. 2026. Dry matter partitioning and yield in *Brassica napus*: insights from ^{13}C isotopes labeling across growth stages. Journal of Soil Science and Plant Nutrition. 210(3): 312-315.

Johansen, T.J., S.F. Hagen, G.B. Bengtsson, J.A.B. Molmann. 2016. Growth temperature affects sensory quality and contents of glucosinolates, vitamin C, and sugars in swede roots (*Brassica napus* L. ssp. *rapifera* Metzg.). Food Chemistry. 196: 228-235.

Jones, B. 2014. Complete Guide for Growing Plants Hydroponically. CRC Press, South Carolina, United States of America.

Kaciusis, M. and G. Samuoliene. 2018. The effect of LED lighting dosage on photosynthetic indices in tatsoi. Research For Rural Development Journal. 2:107-113.

Kiri, I.Z. 2023. A review on plant root architecture and methods for measuring root growth parameters. Dutse Journal of Pure and Applied Sciences. 9(1): 57-66.

Kopsell, D.A. 2017. Light intensity and light quality from sole-source light-emitting diodes impact phytochemical concentrations within *Brassica* microgreens. Journal America Society Horticultural Science. 142(1): 3-12.

Lingga, E.W., G.M.D. Putra, dan I.A. Widhiantari. 2025. Akurasi pengukuran luas daun tanaman pakcoy (*Brassica rapa* L.) berbasis pengolahan citra digital pada sistem hidroponik vertikal dengan suhu dingin pada daerah perakaran. Jurnal Agent. 3(4): 350-368.

Lester, G.E., J.L. Jifon, and D.J. Makus. 2010. Impact of potassium nutrition on food quality of fruits and vegetables: a condensed and concise review of the literature. Better Crops. 94(1): 18-21.

Leszek, A.K., I. Gruss, M. Podlaska, R. Kieloch, and M. Komorowski. 2025. Impact of excessive artificial light at night (ALAN) on species diversity of plants and epigeic insects. Journal of Environment Studies. 20(10): 1-8.

Lopez, J., D.A. Way, and W. Sadok. 2021. Systemic effects of rising atmospheric vapor pressure deficit on plant physiology and productivity. Global Change Biology. 27: 1704-1720.

UNIVERSITAS
GADJAH MADA
Pengaruh Supplementary Light dan Pemupukan Kalium terhadap Morfo-Fisiologis dan Kualitas Sawi Pagoda
(Brassica narinosa L.) pada Sistem Hidroponik Nutrient Film Technique (NFT)
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Lu, Z., W. Hu, X. Ye, J. Lu, H. Gu, X. Li, R. Cong, and T. Ren. 2022. Potassium regulates diel leaf growth of *Brassica napus* by coordinating the rhythmic carbon supply and water balance. Journal of Experimental Botany. 73(11): 3686-3698.

Madasari, Y., B. Ege, dan F.R.E. Wahyuni. 2018. Budidaya Sawi Hijau Secara Organik. Penerbit Lembaga Bahasa dan Budaya Kalimantan, Kalimantan.

Makruf, S.M., L.R. Ramadhan, F. Sandha, P.A.P. Rini, S.A. Najwa, A.H. Amrullah, S. Anatasa, dan A.S. Prastia. 2025. Analisis kelembapan udara terhadap tingginya suhu di sekaran Semarang. Jurnal Analisis. 4(1): 93-100.

Maludin, A.J., M.S. Lum, M.M. Lassim, and J. Gobilik. 2020. Optimal plant density, nutrient concentration, and root zone temperature for higher growth and yield of *Brassica rapa* L. "curly dwarf pak choy" in the raft hydroponic system under tropical climate. Transactions on Science and Technology. 7(4): 178-188.

Mariay, I.F., B.I. Segoro, dan V.L. Tuhumena. 2022. Nisbah daun batang, nisbah berat daun, dan nisbah akar tajuk tanaman sawi pagoda (*Brassica narinosa* L.) akibat pemberian pupuk organik cair kascing, papua nutrient, dan MA-11. Jurnal Agrotek. 10(2): 84-91.

Marschner, P. 2012. Mineral Nutrition of Higher Plants (3rd ed.). Academic Press, Germany.

Mao, B., M. Niu, H. Liu, and J. Wang. 2026. Effect of LED lighting regime on quality of pak choi (*Brassica rapa* subsp. *chinensis*) during cold storage. Foods. 15(10): 1669.

Mehta, A., S. Sharma, H. Gautam, P. Sah, K. Kunwar, and S.S. Pant. 2022. Effects of foliar spray of potassium oxide on vegetative growth and flower quality of gladiolus cv. American beauty. Plant Physiology and Soil Chemistry. 2(2): 79-87.

Mengel, K., and E.A. Kirkby. 2001. Principles of Plant Nutrition. International Potash Institute Publisher, Switzerland.

Miao, C., S. Yang, J. Xu, H. Wang, Y. Zhang, J. Cui, H. Zhang, H. Jin, P. Lu, L. He, J. Yu, Q. Zhou, and X. Ding. 2023. Effects of light intensity on growth and quality of lettuce and spinach cultivars in a plant factory. Plants. 12: 3337.

Miotto, Y.E., C.T. Costa, R. Offringa, J.K. Vehn, and F.S. Maraschin. 2021. Effects of light intensity on root development in a d-root growth system. Frontiers in Plant Science. 12: 778382.

Mukaromah, S.L., J. Prasetyo, B.D. Argo. 2019. Pengaruh pemaparan cahaya LED merah biru dan *sonic bloom* terhadap pertumbuhan dan produktivitas tanaman sawi sendok (*Brassica rapa* L.). Jurnal Keteknikan Pertanian Tropis dan Biosistem. 7(2): 185-192.

Natasya, A.Y., M. Martosudiro, T. Hadiastono. 2014. Pengaruh pemberian tingkat dosis pupuk KCl terhadap infeksi TUMV (*Turnip Mosaic Virus*) pada tanaman sawi (*Brassica juncea* L.). Jurnal Hama Penyakit Tumbuhan. 2(1):

UNIVERSITAS
GADJAH MADA
Pengaruh Supplementary Light dan Pemupukan Kalium terhadap Morfo-Fisiologis dan Kualitas Sawi Pagoda
(Brassica narinosa L.) pada Sistem Hidroponik Nutrient Film Technique (NFT)
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

37-42.

Naufal, A.A. dan Koesriharti. 2025. Pengaruh dosis pupuk nitrogen dan kalium terhadap pertumbuhan dan hasil tanaman sawi pagoda (*Brassica narinosa* L.). Jurnal Produksi Tanaman. 13(7): 491-497.

Niu, G., J. Masabni, T. Hooks, D. Leskovar, and J. Jifon. 2021. The performance of representative asian vegetables in different production systems in Texas. Agronomy. 11(9): 1874-1887.

Novalny, D. 2018. Pengaruh Konsentrasi dan Jenis Nutrisi Terhadap Hasil Tanaman Sawi (*Brassica juncea* L.) Secara Hidroponik Sistem Sumbu. Fakultas Pertanian. Thesis.

Nurhalimah, N., N.M.A. Wedagama, D.N. Ayunani, dan D.A. Safitri. 2023. Korelasi pada karakter komponen hasil terhadap hasil konsumsi galur tanaman sawi (*Brassica juncea* L.). Agrimeta: Jurnal Pertanian Berbasis Keseimbangan Ekosistem. 13(25): 8-14.

Opung, M.K. G. Wijana, dan I.M. Sukewijaya. 2024. Pengaruh *electrical conductivity* (EC) dan jumlah bibit per *netpot* terhadap pertumbuhan dan hasil tanaman pakcoy (*Brassica rapa* L.) pada hidroponik *deep flow technique.* Agro Bali: Agricultural Journal. 7(1): 276-285.

Paolillo, I., G. Costanzo, A. Delicato, F. Villano, C. Arena, and V. Calabro. 2023. Light quality potentiates the antioxidant properties of *Brassica rapa* microgreen extracts against oxidative stress and DNA damage in human cells. Antioxidants. 12(10): 1895.

Palijama, W., J. Riry, dan A.Y. Wattimena. 2012. Komunitas gulma pada pertanaman pala (*Myristica fragrans* H.) belum menghasilkan dan menghasilkan di Desa Hutumuri Kota Ambon. Agrologia: Jurnal Ilmu Budidaya Tanaman. 1(2): 134-142.

Palsha, P.L. and M.W. Iersel. 2024. Morphological and physiological changes of hydroponic lettuce grown in varying potassium concentrations and an adaptive lighting control system. HortScience. 59(8): 1097-1105.

Poorter, H., K.J. Niklas, P.B. Reich, J. Oleksyn, P. Poot, and L. Mommer. 2012. Biomass allocation to leaves, stems, and roots: meta-analysis of interspecific variation and environmental control. New Phytologist. 193: 30-50.

Prajapati, R., S.L. Meena, D. Kumar, S.S. Rathore, C. Varghese, S. Tripathy, D.K. Meena, P.D. Meena. 2024. Yield, nutrient uptake and economics of Indian mustard (*Brassica juncea*) as affected by split and foliar application of potassium. Indian Journal of Agronomy. 69(2): 220-222.

Prianto, J., A.F. Aziez, dan S. Harieni. 2026. Karakter perakaran dan hasil berbagai varietas padi sawah (*Oryza sativa* L.) dengan aplikasi mikoriza pada lahan sawah tadah hujan. Jurnal Ilmiah Agrineca. 26(1): 66-72.

Proietti, S., R. Paradiso, S. Moscatello, F. Saccardo, and A. Battistelli. 2023. Light intensity affects the assimilation rate and carbohydrates partitioning in spinach grown in a controlled environment. Plants. 12(4): 804.

UNIVERSITAS
GADJAH MADA
Pengaruh Supplementary Light dan Pemupukan Kalium terhadap Morfo-Fisiologis dan Kualitas Sawi Pagoda (Brassica narinosa L.) pada Sistem Hidroponik Nutrient Film Technique (NFT)
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Universitas Gadjah Mada, 2026 | Diunduh dari http://etd.repository.ugm.ac.id/

Putra, R.W., B. Syah, dan R.A. Laksono. 2023. Pengaruh kombinarsi media tanam organik dan nilai EC larutan nutrisi terhadap pertumbuhan dan hasil tanaman sawi (*Brassica narinosa* L.H. Bailey) varietas pagoda pada hidroponik sistem wick. Jurnal Igrotech. 13(2): 81-89.

Putri, R.E., S.A. Jatiarum, and Andasuryani. 2025. Optimizing pakcoy (*Brassica rapa* L.) growth in a smart greenhouse: harnessing IoT for temperature and humidity control through tower farming systems. IOP Conference Series: Earth and Environmental Science. 1477(1): 012047.

Rahardian, T.S. 2016. Pemanfaatan Pupuk Hijau Paitan (*Tithonia diversifolia*) dan Krinyu (*Chromolaena odarata*) dalam Peningkatan Hasil Tanaman Brokoli (*Brassica oleracea*). Fakultas Pertanian. Universitas Brawijaya. Skripsi.

Reed, S., R. Schnell, J.M. Moore, and C. Dunn. 2012. Chlorophyll a and b content and chlorophyll fluorescence in avocado. Journal of Agricultural Science. 4(4): 29-36.

Sari, G.L.M., R.R.D. Pertami, dan Eliyatiningsih. 2022. Aplikasi pupuk kalium terhadap pertumbuhan dan produksi tanaman cabai merah besar (*Capsicum annuum* L.). Prosiding Seminar Nasional "Transformasi Pertanian Digital dalam Mendukung Ketahanan Pangan dan Masa Depan yang Berkelanjutan", Jember, 19 Oktober 2022.

Sadowski, J. and C. Kole. 2011. Genetics, Genomics, and Breeding of Vegetable Brassicas. CRC Press, The United States of America.

Samuoliene, G., A. Brazaityte, J. Jankauskiene, A. Virsile, R. Sirtautas, A. Novickovas, S. Sakalauskiene, J. Sakalauskaite, and P. Duchovskis. 2013. LED irradiance level affects growth and nutritional quality of *Brassica* microgreens. Central European Journal of Biology. 8(12): 1241-1249.

Septari, N.F., W.A. Darma, S.U. Putri, and R. Rahhutami. 2025. Growth and yield of pagoda mustard (*Brassica narinosa* L.) under different plant spacings and NPK 16-16-16 fertilizer rates. Journal of Horticulture Production Technology. 3(2): 57-67.

Shafiq, I., S. Hussain, M.A. Raza, N. Iqbal, M.A. Asghar, A. Raza, F.Y. Fang, M. Mumitaz, M. Shoaib, M. Ansar, A. Manaf, Y.W. Yu, and Y. Feng. 2020. Crop photosynthetic response to light quality and light intensity. Journal of Integrative Agriculture. 20(1): 4-23.

Sharma, N., S. Acharya, K. Kumar, N. Singh, and O.P. Chaurasia. 2018. Hydroponics as an advanced technique for vegetable production: an overview. Journal of Soil and Water Conservation. 17(4): 364-371.

Shipley, B. 2006. Net assimilation rate, specific leaf area, and leaf mass ratio: which is most closely correlated with relative growth rate? A meta-analysis. Functional Ecology. 20: 565-574.

Simarmarta, M.T. 2025. The effect of doses of various types of manure and NPK mutiara on the growth and production of pagoda mustard (*Brassica narinosa* L.). Jurnal Penelitian Pendidikan IPA. 11(7): 693-701.

Sipayung, A.H.B. 2024. Respons Pertumbuhan dan Produksi Tanaman Sawi

UNIVERSITAS
GADJAH MADA
Pengaruh Supplementary Light dan Pemupukan Kalium terhadap Morfo-Fisiologis dan Kualitas Sawi Pagoda
(Brassica narinosa L.) pada Sistem Hidroponik Nutrient Film Technique (NFT)
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Pagoda (*Brassica narinosa* L.) Terhadap Pemberian Pupuk Kandang Ayam dan Pupuk Organik Cair Daun Lamtoro. Fakultas Pertanian. Universitas Medan Area. Skripsi.

Song, J., R. Zhang, F. Yang, J. Wang, W. Cai. and Y. Zhang. 2024. Nocturnal LED supplemental lighting improves quality of tomato seedlings by increasing biomass accumulation in a controlled environment. Agronomy. 14(9): 1888.

Susilo, K.R., A. Eu, B. Besemer, Ep. Heuvelink, R.C.H. de Vos, and L.F.M. Marcelis. 2025. Extended photoperiod improves growth and nutritional quality of pak choi under constant daily light integral. Frontiers in Plant Science. 16: 1621513.

Sustr, M., A. Soukup, and E. Tylova. 2019. Potassium in root growth and development. Plants. 8(10): 435.

Szczerba, M.W., D.T. Britto, and H.J. Kronzucker. 2009. K+ transport in plants: physiology and molecular biology. Journal of Plant Physiology. 166: 447-466.

Taiz, L., E. Zeiger, I. M. Møller, and A. Murphy. 2015. Plant Physiology and Development (7th ed.). Sinauer Associates, The United States.

Tanaka, R. and A. Tanaka. 2011. Chlorophyll cycle regulates the construction and destruction of the light-harvesting complexes. Biochimica et Biophysica Acta. 1807(8): 968-976.

Tian, H., H. Sun, L. Zhu, K. Zhang, Y. Zhang, H. Zhang, J. Zhu, X. Liu, Z. Bai, A. Li, L. Tian, L. Liu, and C. Li. 2023. Response of *in situ* root phenotypes of potassium stress in cotton. PeerJ. 11:15587.

Torey, P.C., N.S. Ai, P. Siahaan, dan S.M. Mambu. 2013. Karakter morfologi akar sebagai indikator kekurangan air pada padi lokal superwin. Jurnal Bios Logos. 3(2): 57-64.

Umam, C., S.A. Putri, J. Milyani, S.K. Aurelita, S. Suryawati, dan Y. Purwaningsih. 2023. Perhitungan luas daun berbasis pemrosesan citra digital. Teknotan. 17(2): 115-122.

Vasylkovska, K.V., M.M. Kovalev, O.O. Andrienko, and G.I. Kornicheva. 2022. Technical support for hydroponics, such as progressive type of vegetable cultivation. Journal of Design, Production, and Operation of Agricultural Machinery. 52(1): 81-86.

Virsile, A., A. Brazaityte, V.V. Kairiene, J. Jankauskiene, J. Miliauskiene, G. Samuoliene, A. Novickovas, and P. Duchovskis. 2019. Nitrate, nitrite, protein, amino acid contents, and photosynthetic and growth characteristics of tatsoi cultivated under various photon flux densities and spectral light compositions. Scientia Horticulturae. 258: 1-9.

Wang, M., Q. Zheng, Q. Shen, and S. Gao. 2013. The critical role of potassium in plant stress response. International Journal of Molecular Sciences. 14(4): 7370-7390.

Wang, S., H. Fang, J. Xie, Z. Tang, Z. Liu, J. Lv, and J. Yu. 2021. Physiological

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GADJAH MADA
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responses of cucumber seedlings to different supplemental light duration of red and blue LED. Frontiers in Plant Science. 12: 1-18.

Waruwu, L.S., Y.A. Laoli, A. Laoli, N.Y. Harefa, dan N.K. Lase. 2024. Pengaruh cahaya terhadap pertumbuhan dan perkembangan tanaman kacang hijau (*Vigna radiata* L.). Jurnal Ilmu Pertanian dan Perikanan. 1(2): 120-126.

Wasaya, A., M. Affan, T.A. Yasir, A.Rehman, K. Mubeen, H. Rehman, M. Ali, F. Nawaz, A. Galal, M.A. Iqbal, M.S. Islam, M.E. Sharnouby, M.H. Rahman, and A.E. Sabagh. 2021. Foliar potassium sulfate application improved photosynthetic characteristics, water relations and seedling growth of drought-stressed maize. Atmosphere. 12(6): 663.

Wills, R. and J. Golding. 2016. Postharvest: An Introduction to the Physiology and Handling of Fruit and Vegetables. 6th ed. CABI, United States of America.

Wirayuda, H., Sakiah, dan T. Ningsih. 2023. Kadar kalium pada tanah dan tanaman kelapa sawit (*Elaeis guineensis* Jacq.) pada lahan aplikasi dan tanpa aplikasi tandan kosong kelapa sawit. Tabela: Jurnal Pertanian Berkelanjutan. 1(1): 19-24.

Xiao, M., Z. Li, L. Zhu, J. Wang, B. Zhang, F. Zheng, B. Zhao, H. Zhang, Y. Wang, and Z. Zhang. 2021. The multiple roles of ascorbate in the abiotic stress response of plants: antioxidant, cofactor, and regulator. Frontiers in Plant Science. 12: 598173.

Yang, R., H.Yang, F. Ji, and D. He. 2024. Enhancing the photon yield of hydroponic lettuce through stage-wise optimization of the daily light integral in an LED plant factory. Agronomy Journal. 14(12): 2949.

Yustiningsih, M. 2019. Intensitas cahaya dan efisiensi fotosintesis pada tanaman naungan dan tanaman terpapar cahaya langsung. Bio-Edu: Jurnal Pendidikan Biologi. 4(2): 44-49.

Zhao, S., M. Wu, Y. Chen, Y. Xiong, L. Wang, H. Wang, and M. Li. 2026. Glucosinolates in *Brassica* species: biosynthesis, regulation, and molecular breeding. International Journal of Molecular Sciences. 27(9): 3725.

Zörb, C., M. Senbayram, and E. Peiter. 2014. Potassium in agriculture – status and perspectives. Journal of Plant Physiology. 171(9): 656-669.